

We claim:

1. In a broadband wireless communication system for a multi-user multi-cell environment, a system comprising:

one of multiple transmitters configured to transmit overlaying Multi-Carrier (MC) and Direct Sequence Spread Spectrum (DSSS) signals, wherein:

the MC signal is modulated on subcarriers in the frequency domain;

the DSSS signal is modulated in either the time domain or the frequency domain;

the DSSS signal is aligned with a boundary of a MC slot or a MC symbol in the time domain when the DSSS and MC signals are synchronized, or the DSSS signal is arbitrarily placed in the time domain when the DSSS and MC signals are not synchronized; and

at least one subcarrier of the MC signal can be energized at a different power level, or not be energized at all, and the DSSS signal is transmitted at a power level significantly lower than that of the MC signal.

2. The system of claim 1, wherein:

the transmitter is a part of a base station or a part of a mobile station;

the MC signal is an OFDM or an MC-CDMA;

the DSSS signal is placed at a period of cyclic prefix of an OFDM symbol; and

the system is configured to perform uplink and/or downlink where duplexing technique is either TDD or FDD.

3. The system of claim 1, further comprising one of a multiple receivers configured to receive overlaying MC and DSSS signals, wherein the receiver is a part of a base station or a part of a mobile station and comprises a MC processor and a DSSS processor, and wherein the DSSS processor detects the

presence of a DSSS signal and extracts its information for performing system functions.

4. The system of claim 3, wherein system functions comprise decoding a transmitter's signature in an initial random access, deriving channel information for channel probing, and/or decoding information bit for short messaging.

5. The system of claim 1, wherein digital-to-analog signal conversion dynamic range accommodates both MC and DSSS signals.

6. The system of claim 1, further comprising one of a multiple receivers, the receiver configured to receive overlaying MC and DSSS signals and includes a rake receiver to improve performance in a multi-path environment.

7. The system of claim 1, further comprising one of a multiple receivers configured to receive overlaying MC and DSSS signals, wherein the receiver subtracts the DSSS component of the signal from the received signal to cancel DSSS interference with MC signal.

8. The system of claim 7, wherein multiple step iterative cancellation is applied to improve the effectiveness of DSSS interference cancellation.

9. The system of claim 1, wherein the DSSS signal is power controlled such that its power level is below a specified level at the same time high enough to meet requirements for a receiver to detect or decode the DSSS signal.

10. The system of claim 9, wherein the power level is below a specified level relative to the MC signal power level or noise power level.

11. The system of claim 1, wherein the DSSS signal is power controlled to meet spectrum mask requirements.

12. The system of claim 1, wherein DSSS sequences meet autocorrelation and cross-correlation properties.

13. The system of claim 1, wherein pulse-shaping techniques restrict spectrum mask of DSSS signals and reduce impacts on the MC signals in the frequency domain and wherein a pulse-shaping filter applied to the DSSS signal is a root-raised cosine (RRC) with roll-off factor  $\alpha$  in the frequency domain and impulse response of a chip impulse filter  $RC_o(t)$  is:

$$RC_o(t) = \frac{\sin\left(\pi \frac{t}{T_c}(1-\alpha)\right) + 4\alpha \frac{t}{T_c} \cos\left(\pi \frac{t}{T_c}(1+\alpha)\right)}{\pi \frac{t}{T_c} \left(1 - \left(4\alpha \frac{t}{T_c}\right)^2\right)}$$

where  $T_c$  is the chip duration.

14. The system of claim 1, wherein the DSSS sequences are either binary or non-binary and have spectrum nulls at desired locations.

15. The system of claim 1, wherein DSSS signal utilizes guard periods that overlap with an MC symbol.

16. The system of claim 1, wherein the system employs the DSSS signal for initial random access and the MC signal for high rate data and related control information.

17. The system of claim 1, wherein the system utilizes the DSSS signal in channel probing or sounding for estimation of channel characteristics and wherein the system performs the DSSS channel sounding with or without power control to assist transmission formats and for advanced antenna techniques such as beamforming.

18. The system of claim 17, wherein the transmission formats are modulation types, coding rates, or pilot patterns.

19. The system of claim 1, wherein the system employs the DSSS signal to carry short messages, simultaneously along with its corresponding MC signal, with or without closed loop power control or time synchronization.

20. A communication system for a multi-user multi-cell environment, the system comprising:

transmitter means for transmitting Multi-Carrier (MC) signals;

transmitter means for transmitting Direct Sequence Spread Spectrum (DSSS) signals;

wherein the MC signal carries broadband data and related control signals;

wherein the DSSS signal performs initial random access, channel probing, or short messaging, or a combination thereof;

wherein at least one transmitter means transmits overlaying DSSS and MC signals simultaneously, or wherein at least one transmitter means transmits only the DSSS signals and at least one transmitter means transmits only the MC signals and both DSSS and MC transmitted signals overlay on the same frequency channel, or wherein at least one transmitter means transmits overlaying DSSS and MC signals simultaneously and at least one transmitter means transmits only the DSSS signals and at least one transmitter means transmits only the MC signals and both DSSS and MC transmitted signals overlay on the same frequency channel.

21. The system of claim 20, wherein a subcarrier of the MC signal is energized at a desired power level or not energized at all.

22. The system of claim 20, wherein the DSSS signal is power controlled to reduce interference with the MC signal, and wherein initial power setting of the transmitter,  $T_{MS\_tx}$  (in dBm), is set based on path loss,  $L_{path}$  (in dB), and desired received power level is,  $P_{BS\_rx\_des}$  (in dBm) such that:

$$T_{MS\_tx} = P_{BS\_rx\_des} + L_{path} - C_1 - C_2 ,$$

where  $C_1$  (in dB) is set such that the MC signal's  $SINR_{MC}$  (signal to interference and noise ratio) meets prescribed requirements and where  $C_2$  (in dB) is an adjustment to compensate for power control inaccuracy and where  $SINR_{MC} = P_{MC} / (N+I)$  while denoting  $P_{MC}$  as received power of the MC signal,  $N$  as Gaussian noise, and  $I$  is total interference from all mobile stations in current and other base stations.

23. The system of claim 20, wherein the system controls the DSSS signals power to meet spectrum mask requirements.

24. The system of claim 20, wherein the system applies pulse shaping techniques to restrict spectrum mask of DSSS signals and to reduce impacts on the MC signals in the frequency domain.

25. The system of claim 20, wherein the system utilizes DSSS channel sounding for modulation types, coding rates, pilot patterns, or beamforming, or any combination thereof, with or without power control, to assist transmission formats, for advanced antenna techniques, or both.

26. The system of claim 20, wherein transmission of short messages using the DSSS signaling is with or without closed loop power control or time synchronization.

27. A broadband communication system for a multi-user multi-cell environment, the system comprising:

a receiver capable of receiving a signal that is an addition of Multi-Carrier (MC) and orthogonal spreading code (OSC) signals;

wherein the OSC signals are transmitted at a lower power than the MC signals; and

wherein the receiver employs at least one interference cancellation technique to cancel the interference OSC causes to the MC signal.

28. The system of claim 27, wherein the receiver is a part of a base station or a part of a mobile station and comprises an MC processor and a OSC processor, where the OSC processor detects a OSC signal and extracts information from the OSC signal for performing system functions.

29. The system of claim 27, wherein the receiver includes a rake receiver to improve system performance in a multi-path environment.

30. The system of claim 27, wherein the receiver employs multiple step iterative cancellation to improve the effectiveness of OSC interference cancellation.

31. A broadband wireless communication method for a multi-user multi-cell environment, the method comprising:

- modulating a Multi-Carrier (MC) signal on subcarriers in the frequency domain, wherein a subcarrier of the MC signal can be energized at a desired power level or not be energized at all;
- modulating a Direct Sequence Spread Spectrum (DSSS) signal in the time domain or the frequency domain;
- overlaying the MC and the DSSS signals;
- transmitting the overlaid MC and DSSS signals, wherein the DSSS signal is transmitted at a significantly lower power than the MC signal;
- receiving the overlaid MC and DSSS signals;
- detecting a DSSS signal; and
- extracting the detected DSSS signal information for performing system functions.

32. A broadband wireless communication apparatus comprising:  
a receiver configured to receive a combined signal that includes a first and a second signal modulated under a first and a second modulation techniques, wherein:

the first received signal, modulated in either the time domain or the frequency domain under the first modulation technique, supports multi-cell and multi-user access applications through orthogonal spreading codes, and supports applications requiring better interference averaging than the second modulation technique;

the second received signal, modulated on subcarriers in the frequency domain under the second modulation technique, supports broadband applications requiring higher spectral efficiency and lower vulnerability to multi-path propagation effects than the first modulation technique; and

the first received signal has less power than the second received signal.

33. A broadband wireless communication system comprising:  
a plurality of transmitters, wherein:

at least one transmitter is configured to transmit Direct Sequence Spread Spectrum (DSSS) signals;

at least one transmitter is configured to transmit Multi-Carrier (MC) signals; and

the transmitted DSSS signals are superimposed with the transmitted MC signals in the frequency spectrum.

34. The system of claim 33, wherein at least one transmitter transmits both DSSS and MC signals simultaneously.

35. The system of claim 33, wherein at least one transmitter transmits only the DSSS signals and at least one transmitter transmits only the MC signals, and wherein both DSSS and MC transmitted signals overlay on the same frequency channel.